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Nonlinearity compensation through optical phase conjugation for improved transmission reach/rate

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ABSTRACT

Optical phase conjugation is a well-known technique to provide dispersion and nonlinearity compensation directly in the optical domain. The link properties play an important role in the achievable improvements in transmission reach/rate. Here, we review our recent investigations on the impact of sub-optimum transmission links as well as our effort on the implementation of the optical phase conjugator itself looking beyond using highly nonlinear fibers as nonlinear medium and focusing on integrated silicon waveguides. Preliminary results on combining optical phase conjugation with digital techniques such as probabilistic shaping will also be discussed.

Keywords: optical communication, nonlinearity compensation, four-wave mixing, optical phase conjugation.

1. INTRODUCTION

Signal distortion caused by nonlinearity during transmission is one of the key challenges that must be addressed in order to provide the increase in data rates required by the ever-growing demand for high-speed connectivity. Several nonlinearity mitigation and compensation techniques have been proposed and investigated throughout the recent years [1], focusing on either the digital [1-3] or the optical [4-17] domain. While digital nonlinearity compensation through digital backpropagation can effectively erase the distortion caused by intra-channel nonlinearity [2], the available receiver bandwidth prevents it from compensating for inter-channel effects by using practical receivers. Alternatively, inter-channel effects can be compensated for by using all-optical approaches such as optical phase conjugation (OPC) which potentially enables full-band nonlinearity compensation [2]. OPC has been re-discovered in the past few years with several impressive demonstrations being reported [4-10], however a number of challenges still need to be addressed.

In this talk, we review our recent efforts on investigating the impact of link non-ideality on the nonlinearity compensation provided by practical implementations of OPC, caused by e.g. the inherent wavelength shift introduced by four-wave mixing-based OPC [11, 12] and sub-optimum positioning of the OPC within the link [13]. Additionally, the potential for joint digital and optical compensation by combining OPC with the powerful probabilistic shaping (PS) will be discussed [14]. Finally, we will touch upon the use of nonlinear material for OPC beyond the more commonly used highly nonlinear fibers (HNLFs) [2-6, 8-13] and periodically poled lithium niobate (PPLN) [8], by reviewing our recent results on OPC using silicon waveguides [15-17].

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